NAVAL PERSONNEL AND TRAINING RESEARCH LABORATORY

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A COMPARISON OF STUDENT OPTION VERSUS PROGRAM CONTROLLED CAI TRAINING

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"A Comparison of Student Option Versus Program Controlled CAI Training,"
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SUMMARY AND CONCLUSIONS

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Ninety-six students from BE/E School were divided into four instructional strategy groups for taking the 11 lesson CAI Module.

One training strategy allowed the student to select his training from an index of descriptive lesson objectives. A second training strategy pretested the student immediately before each lesson objective and branched him to appropriate training sequences on the basis of his test results. Each of these two strategies were used with and without a narrative presentation before each lesson to make the third and fourth experimental training conditions.

At the end of training and after completing an attitude questionnaire about their CAI training experience, all four groups took the BE/E School's examination on AC Series Circuits and a supplementary test comprised of school objective criterion questions not represented on the examination.

Findings and Conclusions

No significant differences were found between the four experimental conditions in test performance or training time measures. Questionnaire data indicated that students who selected their own training maintained a significantly more favorable attitude toward CAI. In addition, students who had a pre-training narrative available to them felt that it was a valuable aid.

The best indicators of CAI training success were scores on previous school examinations and prior time spent in the BE/E School's individualized training curriculum. Performance on the CAI module was not significantly related to General Classification Test scores or two aptitude measures.

The findings reported here are the first of two studies designed to evaluate the effectiveness of program controlled versus student controlled CAI training strategies. Research now in progress will evaluate these factors in lesson remediation training.

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by

Patrick H. McCann
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April 1973

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ACKNOWLEDGEMENTS

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A COMPARISON OF STUDENT OPTION VERSUS PROGRAM CONTROLLED CAI TRAINING

I. Introduction

Slough, Ellis, and Lahey (1972) have indicated that additional performance improvement over classroom instruction can be accomplished by individualizing computer assisted instruction (CAI) lesson presentation. When branching instructions are used to permit bypassing instruction that more knowledgeable students do not need, group performance improves significantly both as to time spent and terminal performance. If branching is as effective as these studies have indicated, one may ask how authors should control branching. Hurlock's study (1972) used pretesting as a criterion for making a program-controlled "skip-ahead" or "minimal-maximal training" decision. Slough, Ellis, and Lahey (1972) used a dual-criterion test of performance (branch to additional training if wrong; choice to branch or not branch if correct) for basic control, with a student option for review and practice.

Studies of instructional strategies have not yielded conclusive evidence showing a consistent advantage of one strategy over another based on final examination performance. Dubin and Taveggia (1968) have labeled this finding the "teaching-learning paradox;" they believe there is no difference among truly distinctive methods in college instruction as measured by final examination scores. Davis, Marzoco, and Denny (1970) found that modes of presenting programmed instruction did not produce significantly different learning outcomes nor significant interactions. The modes of presentation were overt versus covert responding and constructed response versus multiple choice. Subjects allowed to choose their own treatment modes did not perform significantly better than subjects whose treatments were experimenter assigned. Further, with the exception of reading, there were no significant interactions with five individual difference measures.

Peeck (1970), on the other hand, found that prequestioning produced significantly better 7-day retention of question relevant prose content than equal prequestion reading time. He suggested that prequestion facilitation of later learning will occur only if the subject remembers the question or recognizes training content as relevant to them. A similar study (Deno, Jenkins, and Marsey, 1970) demonstrated that learning to identify and label the attributes on a subject matter concept prior to training strongly influenced subsequent performance on transfer tasks involving those concepts. Grotelueschen and Sjogren (1968) concluded that, with adults or superior ability, advance organizers may produce facilitative effects on complex learning tasks. Allen (1970) reported a similar effect using advance organizers of approximately 300 words in length written to serve as both expository and comparative organizers. In another comparison of teaching strategies (Coop and Brown, 1970) a teacher structured presentation method of instruction was significantly superior to an independent

problem-solving method of instruction on three achievement measures. Hurlock (1972) reported that pretest branching instructional designs provided two to four times more training experience to the slow learner than to the fast learner.

This study compared two instructional strategies for individualizing lesson training materials and evaluated the effect of reading a lesson narrative before training. The two individualized designs were student option, where the student was allowed to choose his own training, and program control, where lesson programming logics selected the student's training based on his performance on a pretest. It was hypothesized that the availability of a narrative before each lesson would significantly enhance student performance during training. It was also predicted that the individualized training strategies, student option or program control, with the prelesson narrative would produce significantly higher test performance and/or shorter training time than their control conditions without the narrative.

II. Method

A. Design

A 2 x 2 factorial design was used to investigate the influence of two pretraining and two training conditions on performance scores and training time. Random assignment of 96 students among the four experimental conditions allotted an n of 24 students per cell (Table 1). The two pretraining conditions were: (1) a narrative overview read before each CAI module lesson and (2) a non-narrative control condition. The two training conditions were: (1) student option, where each student selected his own training sequences for each lesson and (2) program control, where branching to training was program controlled by each student's pretest performance on each lesson training objective.

TABLE 1

Assignment of Students to Experimental Condition

	Pretraining Condition	
Training Condition	Narrative	Non-Narrative
Student Option	n = 24	n = 24
Program Control	n = 24	n = 24

CAI Lessons 1 and 2 were the same for all Ss; CAI Lessons 3-11 employed the experimental design shown in Table 1. Each lesson was followed by a lesson test that was scored and reviewed for the student. Students failing to reach a lesson score criterion level received remediation before continuing to the next lesson.

B. Subjects

All 96 students were Navy trainees in the Basic Electricity/Electronics (BEE/E) School, Service School Command, Naval Training Center, San Diego, California. During the experimental period, arrangements were made to have trainees at the appropriate time sent to the CAI room to receive the CAI "AC Series Circuit" Module. This procedure was followed until the necessary 96 students were obtained.

C. Equipment

The CAI AC Series Circuit Module was presented on the IBM 1500 Instructional System located at Naval Training Center, San Diego. Each student terminal had a CRT display for presenting training material with a keyboard and light pen for making responses, and an image projector for auxiliary graphics. The instructional system consists of 16 student terminals. Of these, 12 to 13 were used by students in this study, and one as a proctor station to monitor student progress.

D. CAI Training Materials

The CAI training module used in the study was part of a previously operationally tested CAI module, the AC Series Circuits and Resonance Module which corresponded to training objectives taught in the BE/E School. Modifications for the study included adding training objectives not present and deleting training objectives not included in the newly adopted, self instructional, self paced school curriculum. The result was a CAI module containing 11 lessons, called the CAI AC Series Circuit Module.

Beginning with Lesson 3, each lesson was revised into two versions using different training strategy designs, "Student Option" and "Program Control." The Student Option design presented the student with a list or index of topics on the CRT screen from which he could choose his own topic, sequence, and amount of instruction. Each lesson objective was represented by one or more topics. When the student chose a topic, he was immediately branched to a sequence of training frames for that area. After completing a sequence of instruction, he was branched back to the index list of topics. A student could repeat any topic as many times as desired, or he could skip familiar topics and go directly to the lesson test.

The Program Control design started with pretesting. Students were given one or more questions covering each topic in the student option lesson design. The student answering a pretest correctly was branched to

the next pretest; if he failed, he was branched to the appropriate instructional sequence. The student could elect not to answer the pretest question(s) and go immediately to the training. Students were always given training immediately after a failure or upon electing to receive instruction.

Both the Student Option and Program Control designs used identical training sequences for each lesson objective. The only difference in the lesson versions was "how" a student got to the training sequences. In the Student Option design students chose their training topics; in the Program Control design students were branched to the training sequence as a result of low pretest performance or electing to receive the training. Lessons 1 and 2, which were the asme for all students, employed a fixed sequence design with limited branching from mainline presentations.

CAI Lesson Tests were automatically scored on line. Students saw their test score displayed on the CRT screen. If errors were made, the student was branched to a display of the test question with the correct solution. Test questions were usually multiple choice requiring light pen responses.

Following lesson test scoring and wrong answer feedbacks, students were branched to short program controlled remediation sequences to strengthen their understanding of topics missed in the lesson test. Students received additional training specific to errors made on the lesson test. Whether a student received remediation on a particular lesson was based on a cut-off score. After remediation, the student advanced to the next lesson.

E. Off-Line Training Materials

The narrative consisted of separately bound, technically complete lesson material for CAI Lessons 3-11. Lesson narratives were designed so that a student could meet all lesson objectives without taking the CAI lesson. Narratives varied in length from 3 to 14 pages, in some cases including practice exercises, but not programmed instruction materials. Narrative materials were kept at the student terminals.

The students were also provided with Study Guides for CAI Lessons 1-11. This material consisted of brief 2-3 page summaries for each lesson that the student could take with him. Study Guide summaries were not intended to be "stand-alone," technically complete presentations. Occasionally the Study Guide was integrated into the CAI lesson; the student was required to fill in blanks or look at explanatory illustrations within the Study Guide. Typically the Study Guide contained a list of lesson objectives, sample problems, definitions and rules.

F. Evaluation Tests

Two major tests were used to evaluate student comprehension, the BE/E School's Examination and a supplementary test. The supplementary test was given to each student after completing the 11 lessons of the CAI AC Series

Module. The purpose of this test was to measure achievement on lesson objectives taught in the CAI module but not covered in BE/E School's examination. The test consisted of 20 multiple choice questions. It was taken off-line and hand scored by the experiment proctor who reviewed the test with each student. The second test was the BE/E School's (Module) examination; it was administered after the supplementary test. This test contained 40 multiple choice questions.

G. Procedure

The study proctor explained the general nature of the experiment and advised students that the CAI module usually took between two and four days to complete. Students were told not to take notes or make intentional errors in responding. Instruction on the use of lesson narratives stated that narratives were to be read before each lesson (starting with Lesson 3) and that the narrative should not be referred to after starting a lesson. The students were issued Study Guides with the order of lessons listed. It was explained that each lesson is followed by a lesson test and that breaks should be taken at the end of each lesson or at least once per 30 or 45 minutes.

After completing the 11 CAI lessons, each student was given a questionnaire to complete (see Appendix B). The questionnaire differed for the students in the narrative and non-narrative conditions. After completing the questionnaire, each student took the supplementary test and the school's examination.

III. Results

A. Background and Pretraining Measures

Background data from three aptitude tests, the Electronics Technicians Standard Test (ETST), the arithmetic test (ARI), and the General Classification Test (GCT), reported as standard scores are summarized in Table 2. These data were obtained from school records as well as previous school examination scores and previous training time. The previous examinations data shown in Table 2 was calculated by dividing the total number of correct answers by the total number of test questions on 11 school examinations taken before CAI training. The previous training time data was obtained by multiplying the number of days spent in training by 5.5 hours, the duration of a daily shift.

TABLE 2

Background Measures

Test Scores and Previous Training Time	Program Control				Student Option			
	Narrative		Non-Narrative		Narrative		Non-Narrative	
	M	SD	M	SD	M	SD	M	SD
Electronics Technician Selection Test (ETST)	65.0	6.7	63.5	3.7	64.8	5.8	63.0	5.9
Arithmetical Reasoning Test (ARI)	61.0	5.3	59.8	4.3	60.7	5.6	59.8	5.6
General Classification Test (GCT)	63.3	6.1	63.7	3.3	61.3	4.8	61.7	4.0
Previous Examination	90.4	5.1	89.3	4.0	90.0	3.6	89.9	4.3
Previous Training Time (Min.)	819.0	293.8	866.1	227.4	794.3	258.3	746.3	300.9

B. CAI Performance Measures

1. Major Examinations

A multivariate analysis of variance and covariance (Biomedical Computer Program Series, UCLA, BMDX69) was done on performance measures. No significant differences were found for the four experimental groups on module examinations and supplementary test scores, Table 3.

TABLE 3

Module Test Scores (%)

Test	Program Control							
	Narrative		Non-Narrative		Narrative		Non-Narrative	
	M	SD	M	SD	M	SD	M	SD
Supplementary	86.7	13.1	88.6	11.2	88.5	11.7	85.2	9.4
Module Final	84.5	12.0	85.5	9.6	83.8	10.9	82.5	10.8

2. Lesson Tests

The grand lesson score (computed by dividing the total number of correct answers in Lessons 1 through 11 by the total number of lesson test questions) did not differ between treatments (see Table 4). No differences were found between groups on control Lessons 1 and 2.

TABLE 4

Lesson Scores (%)

Lesson No.	Program Control				Student Option			
	Narrative		Non-Narrative		Narrative		Non-Narrative	
	M	SD	M	SD	M	SD	M	SD
1	95.4	7.7	94.5	7.5	91.5	13.4	93.1	10.5
2	79.8	14.2	83.0	10.7	86.4	11.3	84.4	10.3
3	84.9	13.8	86.8	10.9	90.1	7.1	82.9	10.1
4	80.8	11.8	82.6	14.3	85.7	9.0	85.5	12.3
5	85.2	15.6	84.8	13.7	84.5	11.9	87.5	14.7
6	84.8	18.8	90.8*	11.1	93.6*	8.5	85.5	11.5
7	76.6	22.1	84.4	17.7	81.8	15.0	84.8	13.3
8	71.3	20.5	63.3	15.2	73.8	20.8	63.3	22.0
9	70.3	23.8	77.6	17.7	85.8	14.5	76.3	22.0
10	89.6	10.3	84.8	13.1	91.2	9.1	91.9	8.6
11	84.7	13.5	87.5	11.6	86.5	11.6	84.7	8.9
Grand Lesson Score	82.7	13.5	84.5	6.4	87.3	6.1	84.1	6.3

*Interaction $F = 7.75$, $df = 1/96$, $p < .01$

3. CAI Training Time

Only Lesson 10 took significantly less time for two experimental treatments ($F = 12.56$, $df = 1/96$, $p<.001$), Table 5. Lesson training time is the time spent from the start of the lesson to the end of the lesson test. Other times computed by experimental conditions were:

Total Training Time - or the actual time spent on the CAI system by the student. It excludes remediation which may have followed the lesson test.

Module Training Time - the total training time plus time spent on breaks, in remediation after lesson tests, and in review between lessons. It is the clock time spent at the CAI facility from the start of Lesson 0 to the conclusion of Lesson 11.

Time Attended - the total time the student spent at the CAI facility including time taken to review for and complete the supplemental and module tests.

TABLE 5

Lesson Training Time (Minutes)

Lesson No.	Program Control				Student Option			
	Narrative		Non-Narrative		Narrative		Non-Narrative	
	M	SD	M	SD	M	SD	M	SD
1	29.4	4.7	26.4	6.5	28.4	8.4	30.1	7.2
2	43.9	9.5	43.1	9.7	45.6	17.8	48.3	17.3
3	78.0	25.7	82.0	24.7	78.8	34.3	80.9	52.6
4	112.7	35.6	141.7	52.1	118.2	58.4	111.1	49.0
5	45.9	14.1	46.4	11.9	43.8	18.4	40.7	16.8
6	43.4	17.1	44.1	15.8	48.5	28.4	46.8	25.9
7	29.5	8.6	32.9	13.3	28.7	11.4	30.1	13.3
8	34.9	19.5	28.4	13.1	50.9	41.9	39.4	20.8
9	29.5	13.4	28.5	13.4	31.2	17.3	31.8	13.5
10	52.6*	12.2	55.0*	16.1	67.6	27.1	69.6	21.3
11	59.3	19.9	65.6	25.0	50.5	21.3	58.2	20.4
All Lessons	50.8	15.2	54.0	18.3	53.8	25.9	53.4	23.5

*F = 12.56, df = 1/96, p < .001

Time in Other Activities - the time spent in activities other then CAI training. It is equivalent to the "Attendance" minus the "Module Training Time."

Pretraining Time - the time spent reading narratives, taking pretests and reviewing student options.

Table 6 summarizes the mean student times for these categories.

TABLE 6

Training Time

Time (Hours-Minutes)	Program Control				Student Option			
	Narrative		Non-Narrative		Narrative		Non-Narrative	
	M	SD	M	SD	M	SD	M	SD
Hours Training	9:18	1:30	9:54	2:24	9:52	3:43	9:47	3:19
Module Training	11:42	2:08	12:03	2:33	11:40	4:16	12:10	3:59
Attendance	15:18	3:18	15:12	3:20	14:56	5:33	15:35	5:19
Other Activities	3:18	2:00	3:12	1:50	3:16	1:55	3:25	2:04
Pretraining	0:14*	0:05	0:08*	0:03	0:08*	0:04	0:02*	0:01

*Only pretraining times varied significantly between experimental conditions, narrative vs. non-narrative ($F = 52.6$, $df = 1/96$, $p<.001$) and program control vs. student option ($F = 52.65$, $df = 1/96$, $p<.001$).

C. Correlational Analysis

Correlational analyses were performed between the background measures (previous examinations, previous training time, ETST, ARI, GCT) and overall CAI performance measures (Table 7). Previous school examination scores were the best predictors of CAI test performance; prior school training time was the best predictor of CAI training times.

TABLE 7

Correlation Between Background Measures and Overall CAI Performance Measures

Background Measures	Total Tr. Time	Module Time	Hours Attended	Grand Lesson Score	Supp Test	BE/E Exam
Previous School Exams	-0.191	-0.203	-0.356	0.540	0.449	0.629
Previous Training Time	0.505	0.544	0.544	-0.334	-0.247	-0.368
ETST	-0.359	-0.370	-0.475	0.370	0.289	0.411
ARI	-0.276	-0.247	-0.293	0.371	0.382	0.395
GCT	-0.356	-0.357	-0.357	0.159	0.229	0.258

D. Student Attitude Questionnaire

An analysis of the Evaluation Questionnaire, Appendix B, was prepared from student reactions to the CAI instructional system, Table 8. This data is based on 72 student questionnaires or 18 per experimental condition.

TABLE 8

Student Responses to Evaluation Questionnaire

Question No./Rating	Program Control		Student Option	
	Narrative	Non-Narrative	Narrative	Non-Narrative
1. How much did/would the narrative have helped you? (Rated from 0-4, <10% → 90%)	(1) 2.3**	1.3	2.3**	0.8
2. Would the Study Guide have served as a narrative? (Yes = 1, No = 0)	0.3	0.5	0.4	0.6
3. Would you prefer to have training selected for you? (Yes = 1, No = 0)	0.3	0.5	0.4	0.4
4. Did you get enough remediation? (Never-always, 0-4)	(1) 2.9	3.1	3.1	3.2
5. How would you divide your time? (%)				
BEEINLES	37.7	28.0	34.4	26.4
CAI	49.6	66.8	62.2	65.5
Classroom	11.1	1.2	2.8	8.1
Other	1.7	1.5	0.6	0
6. How do you rate CAI? (Poor - outstanding, 0-4)	2.4	3.0	3.4*	3.2*

*$p<.01$, $F = 9.6$, $df = 1/71$
**$p<.001$, $F = 34.0$, $df = 1/71$
(1) interaction, $p<.05$

IV. Discussion

No evidence of the superiority of either of the four training strategies, narrative vs. non-narrative, program control vs. student control, was found in performance scores or training time. The differences in pretraining time for subjects using the narratives disappeared as training progressed, as reflected by overall training times, Table 6. There was no overall benefit from use of the narratives as shown by overall test scores, Table 3.

As can be seen from Table 7, time spent in Basic Electricity/Electronics School prior to CAI training was the best predictor of training times. The grand score on previous examinations also proved to be the best predictor of overall performance measures. The ETST, GCT, and ARI scores were not as good performance predictors as previous performance.

Looking at the mean pretraining time of eight minutes for students who had narratives available to them, Table 6, raises some doubt as to how extensively the narratives were used. Each narrative was designed as self-contained material that met lesson objectives to the point where a fast student could succeed on lesson tests. It was not anticipated that students would spend less than one minute reading them. If there was any preorganization done for the student who read the narrative, it did not seem to influence performance scores or time significantly.

As seen from Question 1, Table 8, those students who had narratives felt they were valuable aids. Question 6, Table 8, revealed a positive attitude toward CAI by the student option group which was not shared by the program control group. Student freedom to control instruction may promote a positive attitude toward training, but in this study it did not improve performance or reduce training time.

It may be that the effects of allowing the student to select his own training sequences and providing him pre-lesson narratives are largely motivational. Given a longer training period, it is possible that the student's positive attitude would result in performance superior to program directed instruction. Conversely, it may be that student chosen sequencing would never prove superior and that student motivation could be increased by offering appropriate incentives and rewards for the student. Rather than rely on either program or student control training, it may be more important to change the total training environment to attract, sustain, and reward the student.

From this study, it is apparent that student controlled and program controlled instruction are equally effective. Further investigation of the students' appraisal of program and student controlled instruction given an opportunity to experience both would be required. The response to Question 1 (Table 8) may have been difficult to answer for those students without the pre-lesson narratives. Giving a narrative to all students who experience both instructional strategies would be worth more study. Application of the experimental design to remedial training after lesson tests in combination with these lesson strategies might point to the significant strengths of each.

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Appendix A

Module 12 - AC Series Circuits

Lessons

(SC-0) Introduction to CAI

A (SC-1) Phase Relationships ┐
B (SC-2) Impedance ┘ Control Lessons

C (SC-3) Trigonometric Functions

D (SC-4) Circuit Analysis

E (SC-5) Vector Notation

F (SC-6) Conversion of Vector Notation

G (SC-7) Power

I (SC-8) Variational Analysis

J (SC-9) Variational Analysis for Power

K (SC-10) Frequency Discrimination in RL Circuits

L (SC-11) Frequency Discrimination in RC Circuits

Appendix B

CAI Experimental Course (SC-Mod 12) Student Number _____

Evaluation Questionnaire (X) for
Non-Narrative Students

1. If you had had a narrative to read before each CAI lesson (like you use in the BEEINLES), how much would it have helped or improved your learning?

none (10%-) some (24%) half (50%) much (75%) all (90%)

2. Would the Study Guide have served as well as a Narrative if you had read it before starting each lesson?

_____ Yes

_____ No

3. If you had your choice, would you prefer choosing your instruction on the computer or would you prefer to be pretested and have the computer decide instruction?

_____ prefer self selection of training.

_____ prefer computer controlled selection of training (pretesting).

4. Did you feel that you received enough remedial practice on incorrect lesson test questions?

_____ never enough (10% or less)
_____ sometimes enough (25%)
_____ half the time (50%)
_____ usually enough (75%)
_____ always enough (90%)

5. Choose the kind of instruction you would like to receive for BE/E training and show percentage of time you would like to spend with each. (You may prefer <u>one</u> or <u>more</u> of training.)

_____ % BEEINLES
_____ % CAI
_____ % Class Instruction with textbook
_____ % Other (specify) _____

6. Rate CAI training: (mark appropriate blank)

poor ___ fair ___ average ___ above average ___ outstanding ___

7. Remarks (likes, dislikes, suggestions for improvement, other comments):

Appendix B

CAI Experimental Course (SC-Mod 12) Student Number _____

Evaluation Questionnaire (N) for
Narrative Students

1. We are interested in your opinion of the use of a narrative (pretraining) before taking a CAI lesson. How much did it help you learning of lesson objectives?

none (10%-) some (24%) half (50%) much (75%) all (90%)

2. Would the Study Guide have served as well as the Narrative if you had read it before starting each lesson?

_____ Yes

_____ No

3. If you had your choice, would you prefer choosing your instruction on the computer or would you prefer to be pretested and have the computer decide instruction?

_____ prefer self selection of training.

_____ prefer computer controlled selection of training (pretesting).

4. Did you feel that you received enough remedial practice on incorrect lesson test questions?

_____ never enough (10% or less)
_____ sometimes enough (25%)
_____ half the time (50%)
_____ usually enough (75%)
_____ always enough (90%)

5. Choose the kind of instruction you would like to receive for BE/E training and show percentage of time you would like to spend with each. (You may prefer one or more types of training.)

_____ % BEEINLES
_____ % CAI
_____ % Class Instruction with textbook
_____ % Other (specify) _____

6. Rate CAI training: (mark appropriate blank)

poor ___ fair ___ average ___ above average ___ outstanding ___

7. Remarks (likes, dislikes, suggestions for improvement, other comments):

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